# The Effect of Coffee Craving on Memory and Feeling-of-Knowing Judgement Accuracy

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## Statement of sources

I declare that this report is my own original work and that the contributions of others have been duly acknowledged.

Signed …….

Date ……

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## Abstract

Broadly, the aim of this study was to replicate the finding that craving—that is, the intense desire for a substance—inhibits cognition, and to see whether this inhibition extends to metacognition. Specifically, this study sought to determine whether coffee craving inhibits memory and feeling-of-knowing (FOK) judgement accuracy. Sixty-seven participants were randomly allocated to a craving or control group. On the day of testing, the craving group abstained from coffee and completed a coffee exposure and imagery task during the experiment. The control group drank coffee as normal and completed a matched exposure and imagery task (jug of water and a holiday). Participants endeavoured to memorise 100 cue-target word pairs. Following an attempt to recall the target word, participants provided a FOK judgement regarding the likelihood of selecting the target in a four-alternative forced choice task (4AFC). Participants then completed the 4AFC task. The control group recalled significantly more target words and selected the correct target word in the 4AFC task significantly more than the craving group, but there was no difference between the two groups in FOK judgement accuracy. These results suggest that although craving inhibits memory, assessment of the quality of one's memory when information cannot be recalled remains intact.

Cravings are a motivational state characterised by an intense desire for a particular substance (Harvey, Kemps, & Tiggemann, 2005). In regard to food and beverage craving, the phenomenon differs to hunger or thirst in that the desire is for a specific substance, rather than to fulfil a basic physiological need (Pelchat, 2002). Cravings occur in a large percentage of the general population (Lafay et al., 2001) and for a variety of legal and illegal substances, including chocolate (Lacaille et al., 2014), alcohol (MacKillop et al., 2010), nicotine (Heckman et al., 2013), methamphetamine (Nakama et al., 2008) and cocaine (Kilts et al., 2001). Craving is integral in the process toward and reinforcement of dependence on a substance (Dunbar, Shiffman, Kirchner, Tindle & Scholl, 2014) and is an important component in the phenomenon of addiction (Fatseas et al., 2015). Craving, therefore, is strongly associated with neurophysiological states that have serious negative health outcomes for affected individuals (Laudet, 2011; Scott, Dennis, Laudet, Funk, & Simeone, 2011).

In addition, it has been consistently demonstrated that craving inhibits cognition (Kemps, Tiggemann, & Grigg, 2008). Craving-related deficits have been exhibited in executive functioning (Uva et al., 2010), working memory (Meule, Skirde, Freund, Vogele, & Kubler, 2012) and language comprehension (Zwaan, Stanfield, & Madden, 2000) for substances including chocolate (Tiggemann, Kemps, & Parnell, 2010), nicotine (Madden & Zwaan, 2001) and alcohol (Ramirez, Monti, & Colwill, 2014).

Stemming from this, the present study had two focuses. Firstly, to replicate the finding that craving inhibits cognition by examining whether coffee craving inhibits memory—more specifically, that it inhibits long-term, explicit memory. Secondly, and more importantly, the aim of this study is to determine whether the

negative relationship between craving and cognition extends to metacognition, and specifically, to feeling-of-knowing (FOK) judgements. Metacognition refers to an individual's knowledge of and ability to regulate their cognitive processes (Brown, 1987), while FOK is a subjective (and often accurate) experience in which individuals feel they "know" information despite their present inability to recall it (Hart, 1965; Hertzog, Dunlosky, & Sinclair, 2010). Critical to this study is the fact that the prominent theory pertaining to the cognitive underpinnings of FOK judgements argues that they are predominantly the result of automatic processing (Koriat, 1993), therefore it is not immediately clear whether coffee craving will inhibit FOK judgements.

## Theories of Craving

The two primary theories that seek to explain why craving inhibits cognitive performance are Tiffany's model (1990) and the Elaborated Intrusion Theory (Kavanagh, Andrade, & May, 2005). Despite differing conceptualisation of the underpinnings of the craving-and-cognition relationship, both are supported by craving induction literature (Kemps & Tiggemann, 2015; Kemps, Tiggemann, & Grigg, 2008). Because both provide foundational theory regarding the relationship between coffee craving and cognitive performance, they are highly relevant to the current research.

### Tiffany's model.

According to Tiffany (1990), consumption behaviour (such as drinking coffee) is stored in long-term memory as an action schema. The specific behaviour, if regularly performed, becomes increasingly automatised and efficient (Thombs & Osborne, 2013). As a consequence, the action requires minimal cognitive resources to implement and is difficult to inhibit if triggered by cues, which can be internal

(e.g., contemplation and rumination about drinking coffee) or external (e.g., smell of a nearby coffee; Brandon, Herzog, Irvin, & Gwaltney, 2004). However, occasionally, situational constraints mean that this typically unrestrained consumption behaviour must be delayed or ignored. For example, an individual might need to forgo their morning coffee because they have an exam (Skinner & Aubin, 2010). According to Tiffany, craving is a behavioural, cognitive and somatovisceral response to consumption impediment (Drummond, 2001). However, the inhibition of the action schema, unlike the schema itself, does not occur automatically; it requires conscious cognitive processing and attention (Vukovic et al., 2008). Because cognitive resources are finite (Cowan et al., 2005), the inhibition of the consumption schema leaves fewer cognitive resources for other tasks (Tiffany & Conklin, 2000). Thus, the craving phenomenon and response impairs coexisting cognitive processing (Kemps, Tiggemann, & Grigg, 2008).

**Elaborated Intrusion Theory.**

According to the Elaborated Intrusion Theory, elaborating on intrusive thoughts through sensory imagery is fundamental to the craving experience (Kemps & Tiggemann, 2010). According to this view, cues (e.g., a television advertisement for coffee) or associations (e.g., the sound of a kettle boiling) related to the desired substance trigger intrusive thoughts (Skorka-Brown, Andrade, & May, 2014). Initially, these thoughts are pleasurable as they share characteristics with the craved substance (May, Andrade, Kavanagh, & Penfound, 2008). The reinforcement received by the pleasure of the thought leads the individual to elaborate and expand upon existing associations through mental imagery (Kemps & Tiggemann, 2009). This cognitive process increases in intensity as elaboration continues, with the imagery becoming more articulate as additional associations from memory and the

environment are incorporated (Field, Munafo, & Franken, 2009). This results in the individual being highly motivated to consume the desired substance; that is, they are in a state of craving (Andrade, May, & Kavanagh, 2012). However, if the individual is deprived of the substance they are ruminating about, the experience becomes unpleasant, particularly if it is interfering with another important cognitive task, such as the individual's work (Kavanagh, Andrade, & May, 2005). Additionally, individuals find it exceedingly difficult to inhibit cravings. Kavanagh and colleagues (2005) argue that thought suppression—a common tactic employed to reduce craving—paradoxically increases the likelihood of rumination (Hill, 2007). Moreover, thinking about another topic during a craving episode creates an association that can then be used as a cue to elicit craving in the future (May, Andrade, Kavanagh, & Hetherington, 2012). As with Tiffany's model, the strength of the Elaborated Intrusion Theory is that it assists in explaining the nature of craving (Lee, Pohlman, Baker, Ferris, & Key-Lambkin, 2010). More importantly, it provides a detailed explanation of the cognitive resources required to attempt to inhibit craving, which in turn explains why craving impairs coexisting cognitive processing (Zwaan & Truitt, 1998).

**Theoretical weaknesses.**

Despite their respective strengths in explaining why craving inhibits cognitive processing, neither theory adequately explains whether craving inhibits automatic, unconscious processing. Logically, the degree to which these uncontrolled processes utilise cognitive resources will dictate their susceptibility to craving. Dual Process theorists argue that cognitive processing is comprised of two systems: an automatic, rapid, subconscious system (1) and a conscious, slow, calculable system (2; Kahneman, 2011; Schneider & Shiffrin, 1977). Furthermore, they argue that system

1 is utilised to minimise cognitive exertion and maximise efficiency through heuristical and habitual processing (Gilovich, Griffin, & Kahneman, 2002). For example, the experienced driver does not consciously change gears or break when presented with relevant stimuli (i.e. red light, change in speed limit), but does so automatically (Speelman & Maybery, 2014). As a result, system 1 processing uses minimal cognitive resources (Hess & Queen, 2015; McBride & Cutting, 2015; Schneider & Chein, 2003). However, it remains to be seen whether the cognitive load of system 1 processing is low enough that it avoids the detrimental effects of craving.

**Metacognition**

As noted earlier, metacognition refers to one's self-knowledge of cognitive processing, as well as the ability to regulate and alter one's cognitions (Meichenbaum, 1985). In short, it is thinking about thinking (Flavell, 1979). More specifically, metacognition encompasses an understanding of how one learns; one's awareness of the presence or absence of understanding; one's judgements of the cognitive resources and strategies required to complete a particular task; and one's assessment of task progress (Cooper, Sandi-Urena, & Stevens, 2008; Gourgey, 2001). Metacognition is different from cognition in that it allows understanding of the nature of the task, whereas cognition is required simply to perform it (Schraw, 2001). For example, when one is studying for an exam, one will encode and memorise the appropriate content—this is a cognitive process. However, at some point one will need to make a judgement of the success of this encoding, and whether the encoding process needs to continue or cease—this is a metacognitive process.

Because metacognition is an integral component of an individual's ability to learn (Veeman, Van Hout-Wolters, & Afflerbach, 2006) and effectively perform a

task (Phelps, Ellis, & Hase, 2001), its utilisation is important in educational (Ahmadi, Ismail, & Kamarul, 2013) and organisational (Nissen, 2007) contexts. Therefore, understanding metacognition processes—and the ways in which they can be enhanced or impaired—can improve the function of those within educational and organisation settings (Perfect & Schwartz, 2002).

**Cognitive mechanisms of metacognition and craving.**

Metacognition, like the vast majority of cognitive processing, involves a combination of subconscious, automatic operation and effortful, voluntary cognitive processing (Kahneman, 2011). For example, while Koriat (2007) argues that individuals have an array of processes and operations that can be consciously and wilfully applied to achieve learning and goal attainment, Reder (1987) states that on occasion, the selection of cognitive strategies used to complete a task is done without conscious understanding of what influences such decisions. Ultimately, the degree to which metacognition is a product of system 1 or system 2 processing is the result of numerous variables, such as which aspect of metacognition is being utilised and the nature of the task (Efklides, 2008). This ambiguity regarding the cognitive nature of metacognitive processes is critical to the current research, because it means that it is not immediately clear whether coffee craving will significantly inhibit metacognition. While the conscious, controlled cognitive aspects of metacognition should be impaired, this may not create a meaningful inhibition of metacognition overall if the automatic, unconscious processes are not considerably impaired also.

**Components of metacognition.**

Traditionally, metacognition has been divided into two sub-components. First, metacognitive knowledge refers to an individual's procedural, conditional and declarative knowledge regarding cognitive strategies, task-related cognition and

general cognition (Pintrich, Wolters, & Baxter, 2000; Schraw & Moshrnan, 1995). Secondly, metacognitive regulation includes the coordination and evaluation of metacognitive knowledge (Fernandez-Duque, Baird, & Posner, 2000; Lai, 2011). However, it has also been argued that metacognitive regulation should be divided further into two independent processes—metacognitive control and metacognitive monitoring (Nelson & Narens, 1990). Metacognitive control refers to the valuation and implementation of factors that influence cognitive processing, and in particular, self-regulated learning (Dunlosky & Metcalfe, 2009; Schneider & Artelt, 2010). These include allocation of study time and selection of retrieval strategy (Smith, Shields, & Washburn, 2003). Metacognitive monitoring refers to the subjective assessment and appraisal of the efficacy of metacognitive knowledge and cognitive processes utilised to achieve learning (Barenberg & Dutke, 2013; Koriat & Shitzer-Reichert, 2002).

**Metacognitive Judgements.**

A fundamental component of metacognitive monitoring is a metacognitive judgement, which is a subjective, probabilistic assessment of learning or memory retrieval based on metacognitive and cognitive processes (Hacker, Dunlosky, & Graesser, 2009; Koriat, 2012). Metacognitive judgements are important because accurate understanding of what one has learnt and has not learnt, or what one can recall and cannot recall, regulates learning, and may lead to alterations in strategy (Handel & Fritzsche, 2015). Thus, metacognitive judgements are pivotal for environments in which efficient learning and accurate retrieval are fundamental components of performance, such as educational (Metcalfe, 2009) and organisational (Dunning, Heath, & Suls, 2004) settings. Metacognitive judgements include judgements of learning, confidence judgements and—of particular interest to the

present study—FOK judgements (Pintrich et al., 2000).

**Feeling-of-Knowing (FOK)**

As briefly mentioned, FOK is a subjective (and often accurate) experience in which individuals feel that they "know" unrecalled information (Hart, 1965; Thomas, Bulevich, & Dubois, 2011). To assess FOK judgements, individuals are typically asked to indicate the probability of future recognition of stimuli that is currently unrecalled (Schmitter-Edgecombe & Anderson, 2007). For example, individuals may be asked to indicate the likelihood (typically from 0-100%) that they would be able to recognise a previously presented, unrecalled word when it is presented amongst numerous alternatives (Efklides & Misaildi, 2010). These judgements of recognition are then compared to actual recognition to provide a measurement of FOK accuracy. High FOK accuracy occurs when there is correspondence between the judgement and recognition, while, low FOK occurs when there is disparity between the judgement and recognition. An example of high FOK accuracy would be if an individual was 90% confident they would correctly select an unrecalled word, and upon presentation of numerous alternatives, they successfully select the previously unrecalled word. Alternatively, if the individual does not successfully select the unrecalled word then FOK accuracy would be low. Furthermore, an individual may be 10% confident that they would select the correct unrecalled word amongst a number of alternatives; if they are unsuccessful in the endeavour then FOK accuracy is high, while if they select the correct unrecalled word then FOK accuracy is low. Previous studies indicate that FOK judgements are at least moderately and positively correlated with subsequent recognition, meaning that items that receive high FOK judgements are more likely to be recognised later than items that receive low FOK judgements (Leonesio & Nelson, 1990; MacLaverty & Hertzog, 2009; Modirrousta & Fellows,

2008). Because FOK pertains to an intriguing cognitive scenario in which individuals have beneficial insight into temporarily inaccessible information (Boduroglu, Pehlivanoglu, Tekcan, & Kapucu, 2015), FOK judgements have garnered research attention in the hope of advancing understanding of the mechanisms and limits of recall and recognition (Koriat, 2000).

FOK judgements are primarily used in contexts which assess the accuracy and quality of one's memory (Yacoby, Dudai, & Mendelsohn, 2015). Such circumstances include an educational examination, the execution of just-learned tasks in an organisational setting, and finally, the selection of a suspect in either an eyewitness identification line-up or an interview. For example, a witness to a robbery may be asked in an interview whether they think they would be able to recognise culprits in a line-up. In this situation, FOK judgements can be provided (i.e. 'I'm 80% confident I would recognise the man with the gun, but only 50% confident that I would recognise the getaway driver.'). Although not decisive, these FOK judgements still provide investigators with valuable information that they otherwise would not have had that assists their judicial processes.

**Accessibility Model.**

The primary theory that attempts to explain the positive relationship between FOK judgements and recognition following inaccessibility is the Accessibility Model (Koriat, 1993). Koriat postulates that FOK judgments are based upon heuristic, mnemonic cues that generally predict memory performance (Hertzog, Fulton, Sinclair, & Dunlosky, 2014; Sacher, Taconnat, Souchay, Isingrini 2009). These heuristic cues include the amount of information recalled (Cohen & Conway, 2007), the ease with which information is recalled (Chaiken & Trope, 1999) and the familiarity of recalled information (Benjamin, 2005). Central to Koriat's theory is

that these predictive mnemonic cues pertain to partial and associated information that may or may not be directly about the target (Sacher et al., 2009). For example, in an exam a student may be presented with a question to which they do not know the answer, yet they are able to recall the specific lecture slide the required information comes from, the day the content was covered in their revision, and other information pertaining to the same topic area. If this information came to the student quickly and a large amount of information was recalled, then according to Koriat, FOK will be high. Finally, Koriat (1993) argues that one cannot monitor and determine the accuracy of the information that stems from these predictive cues, and as a consequence, accuracy of recalled information does not influence FOK judgements (Craik & Robert, 2015).

Koriat's Accessibility Model has substantial empirical support (Schwartz, Pillot, & Bacon, 2014). For example, Koriat (1993) presented thirty Hebrew undergraduate students with forty four-letter consonant strings (a tetragram). Each letter was partial information that contributed to knowledge of the complete tetragram. Koriat found that FOK judgements were higher when participants recalled one, two or three of the letters than when they could not recall any letters. Furthermore, Bacon and Izaute (2009) presented twenty-one schizophrenia patients and twenty-one healthy controls with nonsensical tetragrams. The authors found that FOK judgements increased linearly as a product of the amount of partial information recalled (one, two, three or four letters recalled). Finally, Thomas, Bulevich and Dubois (2012) found that when forty-six participants were presented with sixty cue-target word pairs, the quantity of information pertaining to the target word was more predictive of FOK accuracy than the quality (that is, the accuracy) of that information.

**Accessibility Model and craving.**

A pivotal final assertion that Koriat makes is that FOK judgements are a combination of unconscious and conscious cognitive processing (Vernon & Usher, 2003). He argues that FOK judgements are an automatic by-product of cognitive exertion made during the retrieval process (Sacher et al., 2009). That is, the information that FOK judgements are based on is stored in memory and must be wilfully retrieved, but the FOK judgements themselves are derived from heuristic mnemonic cues (Bayne, Cleeremans & Wilken, 2009). To use system 1 and 2 language, an individual will attempt to retrieve information stored in long-term memory (system 2; effortful, conscious process), and if they are unsuccessful, the subsequent FOK judgements regarding future recognition are based on the familiarity, quantity and rapidity of the just-retrieved information (system 1; automatic, unconscious processing). Therefore, the ambiguity regarding the cognitive construction of metacognition broadly persists regarding FOK judgements, and it remains to be seen whether coffee craving will significantly inhibit FOK judgements. That is, it is unclear if the heuristic mnemonic cues utilised for FOK judgements consume enough cognitive resources that they will be subject to the influence of coffee craving.

**FOK judgement utilisation and craving.**

If craving does not meaningfully inhibit FOK judgements, then when individuals are unable to recall information they will be able to trust the accuracy of their FOK judgements. Alternatively, if craving inhibits FOK judgements, then these judgements become unreliable when information cannot be recalled, which may compromise task performance. For example, if the student who conducts an answerless practice exam is craving coffee, then their FOK judgement for questions

in which they could not immediately recall the answer will be undependable. This means that, in their study following this practice assessment, they may spend unnecessary time on content they know reasonably well (incorrectly low FOK judgement) or inadequate time on content they do not know well (incorrectly high FOK judgement). Both outcomes will be detrimental to exam performance.

## The Present Research

Relating to the present research, there are numerous components and procedures that require explaining and justifying. These include the substance used to create a craving manipulation, the method used to induce craving, the way in which level of craving was measured, and the manner in which FOK judgements were collected and analysed.

### Coffee craving.

Despite the extensive examination of the impact of craving on cognition, the relationship between craving and cognition has not been demonstrated in caffeine (Kemps & Tiggemann, 2009). Caffeine craving can produce a range of negative outcomes, such as depressed mood, fatigue and headaches (Juliano & Griffiths, 2004). This has led to Caffeine Use Disorder being included as a disorder for further study in the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 5th ed, 2013; Meredith, Juliano, Hughes & Griffiths, 2013). Coffee is the most common source of caffeine in Western culture (Frary, Johnson, & Wang, 2005) and is consumed by approximately half the Australian population (Australian Bureau of Statistics, 2014). Furthermore, the prevalence of individuals owning coffee machines and consuming coffee in cafes has steadily increased in Australia in the last five years (Roy Morgan, 2013). Because of the widespread and increasing degree to which coffee is consumed and the negative cognitive

consequences that are suspected to stem from coffee craving, research examining the relationship between coffee craving, cognition and metacognition has important societal implications, and will thus be the focus of the present study.

**Craving induction.**

In the extant literature, cravings are experimentally induced using some combination of abstinence (Tidey, Colby, & Xavier, 2014), imagery (Heishman, Saha, & Singleton, 2004) and exposure (Tiffany, Carter, & Singleton, 2000). All three encapsulate theoretical concepts that are important to Tiffany's model, the Elaborated Intrusion Theory, or both.

Abstinence involves participants forgoing consumption of the craved substance for a period of time before cognitive assessment (Naim-Feil, Fitzgerald, Bradshaw, Lubman, & Sheppard, 2014). Abstinence before testing leads to a significant increase in craving compared to a control condition (Alsene, Li, Chaverneff, & De Wit, 2003; Forman et al., 2007). This is theoretically expected; forced abstinence creates a situational constraint, therefore, according to both theories, all that is required to elicit a craving is an internal or external cue (Kavanagh, May, & Andrade, 2009; Tiffany & Carter, 1998).

Imagery-based craving induction requires participants to imagine, for a short period of time, consuming the craved substance. Studies have demonstrated that imagery leads to a significant increase in craving in comparison to a control group (Green, Rogers & Elliman, 2000; Steel, Kemps, & Tiggemann, 2006; Tiggemann, & Kemps, 2005). These results are anticipated in the Elaborated Intrusion Theory, which argues that imagery is a central component of craving (Kemps, & Tiggemann, 2015).

Finally, exposure can occur through direct contact with the craved substance,

or by exposure to picture or word cues commonly associated with the craved substance (for example, a picture of a café or the word "plunger"; Litt & Cooney, 1999). Exposure to the craved substance or cue leads to a significant increase in craving compared to the control group (Sinha et al., 2009; Smeets, Roefs, & Jansen, 2009; Tong, Bovbjerg, & Erblich, 2007). Again, this is an expected result; both theories argue that cues are a fundamental trigger to the craving experience (May, Kavanagh, & Andrade, 2015; Tiffany, 1995). In summary, because all three of these craving induction methods have strong empirical and theoretical support, each will be incorporated into the present research.

**Craving measurement.**

Researchers have implemented numerous techniques for measuring craving (Rosenberg, 2009); the benefits and weaknesses of the methods unused in the present research will be briefly considered and a justification for the approach undertaken in this research given.

Psychophysiological responses—such as salivation (Teneggi et al., 2002), heart rate (Ooteman, Koeter, Vserheul, Schippers, & Van den Brink, 2006) and skin conductance (Zhao et al., 2012) —and neuroimaging have been used as indirect craving measures. The rationale for this approach is that craving elicits psychophysiological arousal and activates certain regions of the brain, and by measuring the arousal and brain activation, researchers are provided with a craving measurement void of the weaknesses of self-report data (Rosenberg, 2009; Volkow et al., 2013). However, the significant and overarching weakness of such an approach is that psychophysiological arousal and brain region activation may correspond with—but not be directly related to—the craving experience. For example, increased heart rate may be a result of the cognitive and physical exertion required to cope with

abstinence whilst being exposed to a craved substance or associated cues (Sayette et al., 2000), while a brain region may activate if the individual becomes stressed in the presence of craved-substance cues during abstinence (Potenza et al., 2012). As a result, both psychophysiological and neurological measures are an indirect and inaccurate measure of craving.

Finally, craving can be measured through a single-item self-report, which is typically a visual analogue scale (VAS; Drobes, & Thomas, 1999). A VAS is characteristically a 100-mm line anchored by the terms such as "not at all" and "strongest ever experienced," and participants must mark on the line their level of craving (Donovan & Marlatt, 2007). The prominent weakness of a VAS is that it is subject to typical self-report distortions such as constraints on self-knowledge (Paulhus, & Vazire, 2007) and social desirability bias (Hawkshead & Krousel-Wood, 2007). These can lead to either an underestimation or exaggeration of the measurement in question (Lafleur, & Oderda, 2004). However, a VAS has its advantages: firstly, it has good face validity (Mezinskis et al., 2001) and construct validity (Wewers, Rachfal, & Ahijevych, 1990); secondly, it is straightforward to administer and score (Miller, 2013), and finally, it is sensitive to fluctuations in psychological state, such as during craving (Rosenberg, 2009). Because of its advantages and the limited severity of its disadvantages, its extensive use in the literature and the serious shortcomings of the validity of other measures (Di Nicola et al., 2015; Moon & Lee, 2011; Heinz et al., 2006), a single-item VAS will be used to measure each participant's craving in this research.

**FOK judgement measurement and analysis**

Two important methodological inconsistencies exist in the literature regarding FOK judgements: how they are measured (Boduroglu et al., 2015) and

how they are analysed (Sacher, Landre, & Taconnat 2015). Initially, FOK judgements were only collected for unrecalled or incorrectly recalled target stimuli (Lupker, Harbluk, & Patrick, 1991, Nelson, Leonesio, Shimamura, Landwehr, & Narens 1982). However, it has been argued that participants do not know for certain whether their recall is correct or incorrect (Boduroglu et al., 2015). Evidence for this conclusion comes from Koriat (1993), who found that FOK predictions for accurately recalled target stimuli were not 100%. Therefore, if participants are asked for a FOK judgment just for unrecalled or incorrectly recalled targets, then this provides the participant with implicit feedback of their performance (Boduroglu et al., 2015). Specifically, it indicates which target stimuli were successfully and unsuccessfully recalled, which may differ from the participant's FOK as to which target stimuli were correctly and incorrectly recalled. Furthermore, knowing that they are providing FOK judgements for incorrectly recalled and unrecalled stimuli may lead participants to systematically underestimate their FOK judgements compared with having the same procedure conducted for all stimuli. As a consequence, recent studies have collected FOK judgements for all responses, whether correct, incorrect or unrecalled (Baran, Tekcan, Gurvit, & Boduroglu, 2009; Hertzog, et al., 2010; Souchay, Isingrini, & Gil, 2002). Within this, however, there are discrepancies as to which FOK responses are analysed. Some authors analyse only unrecalled FOK judgements (Perrotin, Isingrini, Souchay, Clarys, & Taconnat, 2006; Sacher et al., 2009) while others analyse all responses (Eakin & Hertzog, 2012; Kelemen, Frost, & Weaver, 2000). However, considering that the conceptual definition of FOK is that it is a subjective assessment of memory quality of *unrecalled items* (Bennett & Schwartz, 2013), the current study will collect FOK judgements for all stimuli but will only analyse unrecalled FOK judgments.

**Summary.**

As alluded, the aim of this study was to investigate whether craving inhibits the accuracy of FOK judgements. The study was exploratory, as due to the automatic and conscious cognitive mechanisms involved in FOK judgements, it is not immediately clear whether coffee craving will inhibit FOK judgement accuracy. On the one hand, coffee craving may impair the encoding and retrieval of information in memory, as well as the subsequent FOK judgments made through the heuristic cues employed. This will, in turn, result in inhibited FOK judgment accuracy. This will indicate that enough cognitive resources are utilised by the automatic heuristic cues that they can be distorted by coffee craving. On the other hand, coffee craving may only impair the encoding and recall of memorised information, but not the heuristically-based FOK judgements. As a result, individuals will be recalling less information, but their FOK judgment accuracy will be uninhibited. Again, this will indicate that the heuristic cues upon which FOK judgments are based do not use enough cognitive resources to be meaningfully impaired by coffee craving.

## Method

### Sample Size and Inclusion Criteria

Participants were either members of the general population or psychology undergraduate students (42 females, 23 males and 2 others; $M$ = 28.93 years, $SD$ = 11.70). Undergraduate students received course credit for their involvement, while members of the general population received a $20 Coles/Myer voucher.

Juliano and Griffiths (2004) concluded that 100mg of caffeine—which equates to the average cup of coffee—is enough to produce dependence and subsequent withdrawal symptoms. By extension, it is argued that one cup of coffee a day is enough to produce a craving if consumption is prevented. Therefore, inclusion

criteria required that participants liked the taste of coffee (substance must be desired to be craved; Pelchat, & Schaefer, 2000) and that they drank at least one cup a day.

Because the effect of craving on metacognition is a novel research area, the appropriate effect size—and subsequent sample size—cannot be determined a priori. Therefore, current recommendations for group comparison (minimum of 20 participants per group) were adhered to (Simmons, Nelson & Simonsohn, 2011).

**Materials and Procedure**

Participants indicated interest in study participation via email and were given the opportunity to select a suitable testing timeslot. Times ranged from 9:00am-5:00pm. The time slot was then randomly allocated (using a random number generator) to be either a control ($N$ = 32) or craving ($N$ = 35) condition. The experiment itself was conducted in a quiet laboratory room, with each session taking approximately sixty minutes. Participants were tested individually, in pairs or in groups of three. Upon arrival, participants were asked to complete a brief demographic questionnaire, to sign a consent form and to read the experiment instructions before they began the experiment (see appendix A).

**Craving manipulation.**

Participants were notified by email forty-eight hours prior to testing of the requirements of their condition (Baylen, 2007; see appendix B). Participants in the craving condition were required to abstain from consuming coffee on the day of their testing, and were asked if they had complied with this instruction upon arriving at the laboratory (Kemps, & Tiggemann, 2009). Juliano and Griffiths (2004) found in their review that onset of withdrawal symptoms occurred 12-24 hours after abstinence. Therefore, it is argued that it is unnecessary to extend abstinence beyond the day of testing. Participants in the control condition were asked to continue consuming

coffee as normal.

Once participants had read the information sheet, had given their consent to participate and had completed the first part of the cognitive and metacognitive assessment, they were moved to another room to conduct an imagery and exposure task. Participants in the craving group were presented with a jug of fresh black coffee brewed in a plunger. It was stated that under no circumstances were they allowed to consume the beverage. A scripted procedure, adopted from Baylen's (2007) study, was then read out by the experimenter (see appendix C). This method was utilised because it contained previously-discussed, empirically and theoretically supported craving-induction mechanisms; namely, exposure and interaction with the craved substance ('Pick up the jug of freshly made coffee and pour yourself a cup'), and mental imagery with strong sensory components ('Pay attention to the smell and colour of the coffee, and imagine what it would be like to have a cup of your favourite coffee right at this moment.').

In the control condition, the content of the script was replicated, except participants were presented with a jug of water and were asked to imagine being on their favourite holiday (Baylen, 2007; see appendix C). The holiday scenario is an appropriate control match because it is desirable and adaptable to each individual, but is unrelated to either food or beverage.

**Cognitive and metacognitive assessment**

To assess FOK judgement accuracy, participants were initially presented with 100 cue-target word pairs (for example, POND –BOOK) that required memorisation. Participants were notified that their memory of the target word would be assessed at a later time point through presentation of the associated cue (Perrotin, Tournelle, Isingrini, 2008). Word pairs were presented on a Microsoft Windows XP computer.

All pairs were presented in capitals, size thirty-six, Times New Roman font against a white background and with a resolution of 1024 × 768 on the program E-Prime (Psychology Software Tools, 2012). Word pairs appeared one at a time and study was self-paced (see appendix D).

Following the completion of the exposure and imagery task, participants returned to the other room and completed a metacognitive exercise (judgements-of-learning) to fulfil requirements for an alternative study. Immediately after this, participants were presented with the cue word for each word pair, and were asked to recall the target word (for example, POND - ?; see appendix D). Once again, participants had an indefinite timeframe to spend on each word pair. It was emphasised in the instructions that if they did not know the answer it was preferable to leave the space blank. Once this was completed, participants were once again asked to return to the other room to complete the exposure and imagery task. It is important to note that the exposure and imagery tasks were timed so that they would be directly prior to the metacognitive judgements (see appendix E). This is because, theoretically, craving for coffee should be at its highest in the period just after exposure and imagery, before it begins to diminish as time elapses. As a consequence, it is integral to collect FOK judgement data as soon as possible following the craving induction procedure, and it was thought that this methodology would most accurately and directly assess the hypothesis that coffee craving would inhibit FOK judgements.

Therefore, following the exposure and imagery task, participants returned to the other room and provided FOK judgements. They were presented a cue word (for example, POND) and were asked ‘Will you be able to recognise the matching word from a list?’ Participants were required to respond with a number from 0-100, with 0

representing ‘definitely not’ and 100 ‘definitely yes’ (see appendix D). Once this had been done for each word pair, a four-alternative forced-choice (4AFC) recognition task was presented for each cue word (for example, POND - ?: KILT, SALT, BOOK, FOWL), and participants attempted to select the target word (see appendix D).

Each word-pair component of the experiment (initial presentation, recall, FOK judgements and 4AFC task) was presented in two blocks of 50. Between blocks, participants had an enforced break of thirty seconds. During this break, a picture of a coffee was presented to the craving group on E-Prime, while a picture of a beach and palm trees was presented to the control group (see appendix D).

**Word-pair and 4AFC word selection process**.

Word pairs were formed using the MRC Psycholinguistic Database and two independent methods. Firstly, the parameters of imaginability (200-600) and concreteness (300-700) were kept constant while the variable of familiarity was varied to create low (100-349), medium (350-499) and high (500-700) conditions. Secondly, all parameters were set to a particular numerical value (for example, 300-399). The accumulation of these methods resulted in 187 word pairs, of which 100 were randomly selected. Only nouns were used and the cue and target word of each pair were matched for number of letters (ranging from four to six). Word pairs were semantically unrelated, as in previous research (Alam & Shimul, 2014; Hertog & Touron, 2011; MacLaverty & Hertog, 2009), to ensure the procedure would be a novel learning process.

Alternative (i.e. non-target) words for the 4AFC task were selected using the MRC Psycholinguistic Database and matched the target word in parameters for familiarity, concreteness, imagability and length. Again, all words were nouns and were semantically unrelated to the cue or target word to avoid providing an

additional mnemonic cue for retrieval that was not present when FOK judgements were made.

**Manipulation check.**

Upon conclusion of FOK testing, participants' craving for coffee was assessed for four time points; upon entering the laboratory, after the first exposure and imagery task, after the second exposure and imagery task, and upon completion of the experiment. Participants indicated their level of craving on a VAS to a question relating to the specific time-point (for example, 'When you first arrived here, how strong was your desire for coffee?'), with the extreme left-hand side of the line stating 'no desire (0%)' and the extreme right-hand side stating 'extremely strong desire (100%)' (see appendix C). Participants were also required to complete a coffee-adapted trait craving questionnaire (Benton, Greenfield, & Morgan, 1998) and a coffee-adapted caffeine dependence questionnaire (West & Roderique-Davies, 2008) to provide baseline measurements for analysis (see appendix C). Finally, participants were given a debrief information sheet which stated the purpose of the experiment, as well as the reason why this was not fully disclosed prior to consent (see appendix A).

## Results

Before analyses were run the data was checked for anomalies. Four participants had to be excluded due to a programming error (4AFC responses not recorded), while an additional participant was excluded because they did not like coffee, as indicated in the Attitudes to Coffee Questionnaire. Forty-two FOK judgements that exceeded the range of 0-100 were either transformed to a probable alternative (for example, a judgement of '1000' changed to '100') or deleted if there was no plausible alternative (for example, '1321'). Target-word recall responses

were also considered correct and subsequently altered if there was a spelling (i.e. 'arbor' instead of 'arbour') or simple grammatical (i.e. 'dives' instead of 'dive') error (see zip file).

In the following analyses Cohen's d is the effect size reported for t-tests (small effect = 0.2, moderate effect = 0.5, and large effect = 0.8; Cohen, 1988), while partial eta squared is the effect size for the mixed factorial ANOVA (small effect = .01, moderate effect = .06, large effect = .14; Cohen, 1988).

**Craving Manipulation**

**Average daily coffee consumption.** A t-test revealed that there was no significant difference between the control group ($M$ = 1.97, $SD$ = 1.031) and craving group ($M$ = 2.06, $SD$ = .968) in average daily coffee consumption, $t(65) = .362$, $p = .719$, $d = .09$. Thus, average coffee consumption has been partitioned evenly between the two groups, strengthening the validity of our craving manipulation.

**Liking coffee.** There was no significant difference between the control group ($M$ = 6.44, $SD$ = 1.05) and the craving group ($M$ = 6.34, $SD$ = .84) in relation to the statement, 'I like the taste of coffee,' with 0 being 'not quite like me' and 7 being 'very much like me,' $t(65) = .41$, $p = .683$, $d = .11$. This indicates that the enjoyment of coffee for both groups was high, and that there was no discrepancy between the two groups in enjoyment of coffee, which was an inclusion criterion for the experiment.

**Last coffee.** There was a significantly greater average time lapse, in hours, since the craving group had last had a coffee ($M$ = 12.09, $SD$ = 2.75) compared to the control group ($M$ = 4.69, $SD$ = 4.87), $t(65) = 7.744$, $p < .001$, $d = 1.89$. This indicates that, on average, the craving group did indeed abstain from coffee on the day of testing, and that the control group, on average, continued to drink coffee as normal

on the day of testing.

**Consuming other caffeinated beverages.** A t-test revealed that there was no significant difference between the craving ($M$ = .38, $SD$ = .493) and control group ($M$ = .56, $SD$ = .504) in the consumption of other caffeinated beverages prior to testing, $t(64) = 1.467$, $p$ = .147, $d$ = .36. Although this result is not significant, the small-to-moderate effect size indicates that the craving group minimally compensated for their coffee abstinence prior to testing through increased consumption of other caffeinated beverages.

**Level of craving across time-points.** Finally, a 2 (group: craving, control) x 4 (time-point: beginning of experiment, post first exposure and imagery task, post second exposure and imagery task, conclusion of experiment) mixed factorial ANOVA was conducted to examine craving levels, as measured by the VAS, for the control and craving groups at each of the four time-points. Although the assumption of sphericity was violated, $p$ = .001, all other assumptions were met, therefore it was deemed appropriate to interpret the ANOVA with a Greenhouse-Geisser correction. Furthermore, although Levene's test of homogeneity of variance was violated for the second induction and exposure task, $p$ = .005, the fulfilment of all other assumptions meant that the ANOVA was still trustworthy to interpret.

There was a significant main effect of group, $F(1, 65) = 48.11$, $p$ <.001, $\eta_p^2$ = .425. An examination of Figure 1 indicates that for each time-point, the craving group had significantly higher levels of craving than the control group:

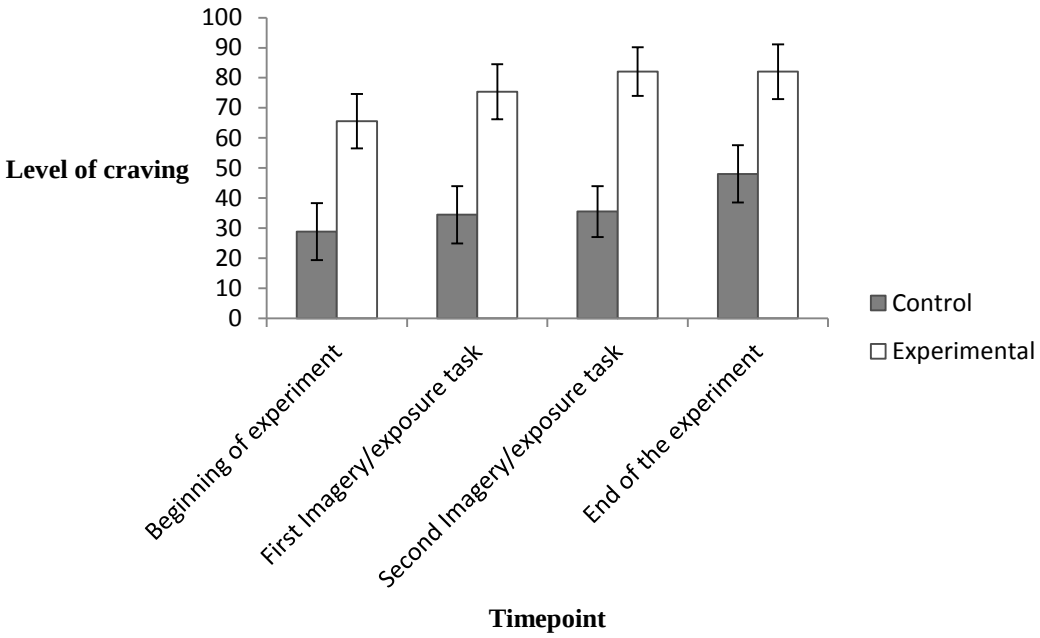


*Figure 1.* Mean level of craving for the control and craving group at each time-point with 95% Confidence Intervals.

Furthermore, there was a significant main effect of time-point, $F(2.56, 166.34) = 19.16$, $p < .001$, $\eta_p^2 = .23$, following a Greenhouse-Geisser correction. An examination of Figure 1 indicates that regardless of group, the level of coffee craving increased across time-points.

Finally, the Group x Time-point interaction trended towards significance, $F(2.56, 166.34) = 2.59$, $p = .054$, $\eta_p^2 = .038$, following a Greenhouse-Geisser correction, although the effect size is negligible. This indicates that the difference in level of craving between the control and craving group differed across time-points. Specifically, it highlights that there was a greater increase in level of craving in the craving group compared to the control group across time-points until the final time-point (see Figure 1). In the final time-point it appears that there is a ceiling effect for the craving group, while the control group has an increase in coffee craving due to the presentation of a cue (i.e. being asked how much they are craving coffee at that

moment).

## Cognitive Tasks

This experiment involved two memory tasks. Firstly, the attempted recall of the target word upon presentation of the cue word, and secondly, the selection of the target word in the 4AFC task. Because our craving manipulation has been successful, we would expect that in both these tasks, the control group would perform significantly better than the craving group.

**Target-word recall.** In the target-word recall task, the control group ($M$ = .20, $SD$ = .20) recalled significantly more target words than the craving group ($M$ = .09, $SD$ = .12), $t(65) = 2.62$, $p = .011$, $d = .75$.

**4AFC recognition task.** In the 4AFC recognition task, the control group ($M$ = .62, $SD$ = .24) selected the appropriate target word significantly more than the craving group ($M$ = .51, $SD$ = .20), $t(65) = 2.07$, $p = .042$, $d = .51$. Both of these results provide strong evidence that the craving manipulation has impaired memory performance.

## FOK Accuracy

To determine FOK judgement accuracy, participants' FOK judgements are compared with their subsequent recognition in the 4AFC task (Busey, Tunnicliff, Loftus, & Loftus, 2000). Three statistical measures are utilised to provide a comprehensive understanding of the extent to which FOK judgements predicted subsequent recognition; calibration (C), over-under confidence (O/U) and resolution (Yang & Thompson, 2010).

**Calibration.** Calibration reflects the degree of correspondence between FOK judgements and subsequent recognition (Hanczakowski, Zawadzka, Pasek, & Higham, 2013). If calibration is perfect, then for trials when participants provided

FOK judgements of 50%, subsequent recognition accuracy would also be 50% (Lampinen, Neuschatz, & Cling, 2012). The calibration statistic reflects deviation from perfect calibration, with 0 representing perfect calibration and 1 a complete absence of calibration (Weber & Brewer, 2003). Calibration is mathematically calculated as follows, with *J* representing a class interval (i.e. FOK judgements between 50-60, 60-70, etc.), $c_j$ representing mean confidence, $a_j$ the proportion of correct responses, $n_j$ the number of observations for each class interval and *n* the total number of observations (Brewer & Wells, 2006):

$$C = \frac{1}{n}\sum_{j=1}^{J} n_j(c_j - a_j)^2.$$

It is also beneficial to examine the judgement-recognition relationship visually on a plot known as a calibration curve (see Figure 2), as this allows comparison of groups against each other and perfect calibration for varying levels of either confidence or recognition (Palmer, Brewer, Weber, & Nagesh, 2013):

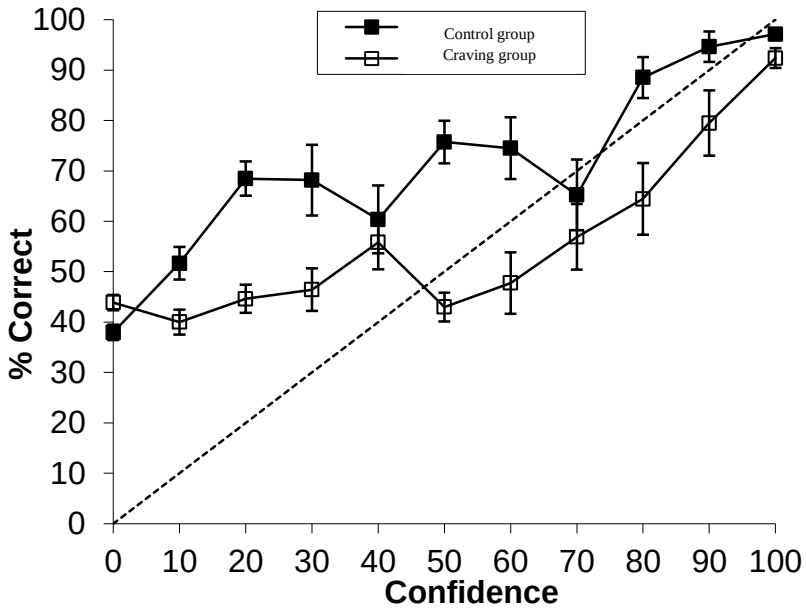


*Figure 2*. Calibration curve of FOK judgements and correct selection of target word in the 4AFC recognition task. Perfect calibration indicated by the dotted line.

Visually, there is minimal discrepancy in the pattern of the values between the two groups; there is a general linear trend of increased recognition as confidence increases, particularly when confidence exceeds 70%. Supporting this, it was found that there was no significant difference in calibration between the control group ($M$ = .14, $SD$ = .10) and the craving group ($M$ = .13, $SD$ = .11), $t(65) = .28$, $p = .780$, $d$ = .07.

**Over/Under confidence.** The O/U statistic averages over/under confidence across trials (Sauer, Brewer, Zweck, & Weber, 2010). If average confidence is higher than overall recognition then this represents over-confidence, while if average confidence is lower than overall recognition then this represents under-confidence (Gigerenzer, Hoffrage, & Kleinbolting, 1991). Within the O/U statistic, -1 represents absolute under-confidence (0% confidence, 100% recognition) while 1 represents absolute over-confidence (100% confidence, 0% recognition; Weber & Brewer,

2004). Mathematically, it is calculated using $\bar{p} - \bar{e}$, with $\bar{p}$ denoting mean confidence and $\bar{e}$ denoting mean recognition (Yang, Thompson & Bland, 2012). As with the calibration statistic, there was no significant difference between the control group (*M* = -.26, *SD* = .18) and the craving group (*M* = -.22, *SD* = .21) in the O/U statistic, *t*(65) = .945, *p* = 348, *d* = .23, with both groups averaging slight under-confidence for total recognition.

**Resolution.** Finally, resolution is the extent to which FOK judgements predict recognition (Yaniv, Yates, & Smith, 1991). Resolution is determined using the Adjusted Normalised Resolution Index (ANRI) statistic, with 0 representing a complete inability to predict recognition through confidence and 1 a perfect ability to predict recognition by one's confidence (Sauer, Weber & Brewer, 2012). Mathematically, it is calculated as follows (symbol representation equivalent to the calibration statistic; Brewer & Wells, 2006):

$$ANRI = \frac{\left(n\left(\left[\frac{1}{n}\sum_{j=1}^{J} n_j(a_j - a)^2\right] \div a(1-a)\right) - j + 1\right)}{n - j + 1}$$

There was no significant difference in resolution between the control group (*M* = .10, *SD* = .12) and the craving group (*M* = .07, *SD* = .07), *t*(63) = 1.53, *p* = .130, *d* =.38. Each of these three statistical analyses (calibration, over/under confidence and resolution) strongly indicate that coffee craving did not impair FOK judgement accuracy.

## Discussion

The present research established two important findings. Firstly, the coffee craving group had significantly lower memory performance, as exhibited in target-word recall and the 4AFC task, than the control group. The only previous study to

examine coffee craving was Kemps and Tiggemann (2009), who examined whether imagery could reduce coffee craving. Therefore, the examination of the relationship between coffee craving and cognition was novel, as was the subsequent finding that coffee craving inhibited memory. Secondly, there was no significant difference between the control and craving group in FOK judgement accuracy, which indicates that craving does not interfere with the accuracy of FOK judgements.

From these results, several conclusions can be drawn. Firstly, the finding that there was no significant difference in FOK judgement accuracy between the control and craving group provides support for Koriat's (1993) Accessibility Model and the assertion that FOK judgements are the result of automatic cognitive processing. Specifically, the results suggest that the automatically-processed, heuristic mnemonic cues that FOK judgements are based upon—the amount, rapidity and familiarity of information recalled—require such minimal cognitive resources that they are not susceptible to the detrimental influence of craving. It should also be noted that previous research on Koriat's theory has focused solely on determining the heuristic cues that determine FOK judgements (Hertzog et al., 2014; Sacher et al., 2009; Thomas et al., 2012) and although Koriat makes a compelling theoretical argument for FOK judgements to be automatic (Koriat, 1993; 2000), this is the first study to provide empirical evidence to suggest that this is indeed the case.

Secondly, the finding that those in the craving group had significantly lower memory performance than the control group is consistent with previous literature and the finding that craving inhibits general cognitive performance (Uva et al., 2010; Zwaan et al., 2000) and memory specifically (Meule et al., 2012; Zuj, Palmer & Kemps, 2015). In addition, impaired memory performance in the craving group provides tentative support for both Tiffany's model and the Elaborated Intrusion

Theory. However, because components of both theories were incorporated into the study, it is impossible to determine which aspects of the craving experience were due to which craving induction techniques. For example, although craving increased during the exposure and imagery task for the craving group, it is impossible to determine whether this was the result of imagery, which would support the Elaborated Intrusion Theory (Kemps & Tiggemann, 2015), exposure to cues, which is integral to both theories (May, Andrade, Panabokke, & Kavanagh, 2004), or abstinence, which, again, is accounted for in both theories (Andrade, May, & Kavanagh, 2008; Nichols & Wilson, 2015), or, if it is a combination of all three, what degree of craving is attributable to which induction technique. In conclusion, it can only be suggested that the general underlying assertion of each theory—that craving inhibits cognition—has been supported, as opposed to claiming that the results have refuted or supported specific mechanisms of either theory.

Finally, the collective result of impaired memory performance in the craving group but no difference between the craving and control group for FOK judgement accuracy provides support for Koriat's Accessibility Model. Specifically, it offers evidence for Koriat's assertion that FOK judgements are based upon explicit, conscious cognitive processing (system 2), while the FOK judgements themselves are the result of automatic, subconscious processing (system 1).

## Implications

### Cognition, Metacognition and Craving.

These results suggest that individuals who crave substances in memory assessment contexts—whether it be coffee, alcohol, an illicit drug, or a range of other substances—can trust their FOK judgements, knowing that they are not subject to the impairment that accompanies craving. However, these results also suggest that the

accuracy and quality of cognitive processing—and most pertinently the ability to retrieve information from memory—of these individuals in such circumstances is likely to be impaired. Importantly, these deficits are not slight; the craving group recalled less than half of the words that the control group did in the target-word recall task, while they also selected the correct target word in the 4AFC task 20% less than the control group. Such retrieval deficits could be the difference between a pass or a fail in an exam, a promotion or relegation in an organisational context, or a successful or unsuccessful selection of a guilty suspect in a witness identification task. From these conclusions, the overarching implication that can be drawn from this research is that craving will inhibit memory performance, but individuals will still have a relatively accurate assessment of the quality of this impaired memory when information cannot be recalled.

Stemming from this conclusion—impaired memory, but accurate assessment of unrecalled memory—numerous recommendations and repercussions can be highlighted. Firstly, Zunhammer, Eichhammer and Busch (2014) found that caffeine consumption significantly increased in university students during the exam period. It is important that such students—as well as students who have been habitually consuming coffee all semester—ensure that their coffee consumption routine does not coincide with their exam schedule, otherwise, there is the distinct possibility that the individual will crave coffee in the exam, which will inhibit retrieval of information from long-term memory, as well as cognition more generally. For example, it is ill-advised for a student to drink coffee habitually at 10:00am during study in the lead-up to the exam when this student has an exam scheduled from 9:00-11:00am. However, if a student does find themselves in this unfortunate position, their FOK judgements pertaining to their memory— albeit impaired memory—will

be accurate. This is particularly useful in a multiple-choice context, as even individuals craving during an exam will be able to appropriately allocate their resources (time, cognitive processing) to certain questions but not others depending on the strength of their FOK judgements for questions they are unsure of.

Although individuals in an organisational context typically rely on automated processes that have been consolidated in long-term memory through extensive repetition (Bargh, Lee-Chai, Barndollar, Gollwitzer, & Trochel, 2001), there may also be times when one needs to learn a novel task or procedure (i.e. a new computer system has been initiated, there's been a change in leadership, leading to a change in process, etc.). It is recommended that in both the encoding and retrieval process that the individual ensures that they have satiated their coffee craving, if it is present. Furthermore, it is recommended that such information is not taught (encoding) or tested (retrieval) during times in which individuals typically consume coffee, such as morning or afternoon tea. However, if an employee finds themselves in a situation in which recently encoded information is being tested but they cannot recall the information (such as the utilisation of a new procedure), their FOK judgements will still be accurate. This information can then be used to determine whether they seek assistance (low FOK) or continue in the manner that they believe to be appropriate (high FOK).

Finally, it is important that law enforcement agencies (such as the federal and state police) understand the detrimental impact that coffee craving can have on memory retrieval, and therefore, the negative consequences this phenomenon can have on their investigative and judicial processes. While it is likely that the adverse influence of fatigue or intoxication on cognition in such contexts is understood (Danziger, Levav & Avnaim-Pesso, 2011), the detrimental effect of coffee craving is

unlikely to be fully appreciated  As a consequence, it is recommended that, firstly, they do no conduct interviews or witness identification line-ups during typical morning and afternoon tea hours, and secondly, that they offer individuals who are about to engage in such processes a coffee before they begin to reduce the risk of coffee craving. However, it is important to note that even if an individual is craving coffee in such a context, FOK judgements remain accurate and thus still provide useful information in an investigation. Pertinent circumstances in which these judgements are beneficial include providing information relevant to a case that cannot explicitly be recalled in an interview (for example, 'I'm 75% confident that he said he was going to the supermarket that afternoon'), or selecting a suspect in an eyewitness identification line-up despite absence of recall (for example, 'I'm 60% confident that is the guilty individual').

**Coffee Craving.**

Finally, and most broadly, this research highlights a potentially underappreciated drawback of regular coffee consumption; decreased cognitive performance if the substance is craved. It has also been established in other research that coffee withdrawal produces headaches, fatigue and mood disturbances (Juliano, Huntley, Harrell, & Westerman, 2012). Furthermore, it has been previously demonstrated that the positive effects of coffee, such as enhanced subjective well-being, increased arousal and higher levels of concentration (Temple, Dewey, & Briatico, 2010), decrease over time as dependence is established and the individual becomes tolerant to the drug (James & Rogers, 2005). In light of such information, the appropriateness of the recent increase in coffee consumption—and it is presumed, coffee dependence—must be queried. This is not to advise that individuals should completely cease drinking coffee, or that it is a highly dangerous substance

comparable to alcohol or illicit drugs. Rather, it is to suggest that, on the whole, tne negative consequences of those who are dependent on coffee potentially outweigh the positive consequences, particularly if they are deprived of the substance.

**Limitations**

This experiment contained two noteworthy limitations. Firstly, participants were asked to provide measurements for level of coffee craving at the conclusion of the experiment for three time-points, rather than immediately after the time-point had elapsed. Retrospective assessments utilise an individual's episodic memory, which is prone to error and systematic bias. Individuals reconstruct events and their subjective experience using heuristics and fragments of memory (Schacter & Addis, 2007; Shiffman, 2000). Ironically, the craving experience itself may accentuate the impairment of both memory storage and recall due to the division of cognitive resources. This increases the likelihood of underestimation or overestimation of level of coffee craving. However, if level of craving was assessed immediately after the time-point had elapsed, the control group could have inadvertently been induced into coffee craving due to the presentation of a cue (Madden & Zwaan, 2001). Considering the nature of the research and that it relied upon craving being induced in the craving and not the control group, it was decided that potential measurement error in the manipulation check data was more appropriate than reducing the integrity of the craving induction process, which had the potential to significantly undermine the results of the main analyses relevant to critical research questions (i.e. whether coffee craving inhibit FOK judgements). Furthermore, it is an approach that has been utilised consistently by other researchers (Green et al., 2000; Kemps et al., 2008).

Secondly, the experiment was conducted in an artificial, laboratory setting, which reduces the mundane realism and ecological validity of the results. Although

the craving-induction techniques utilised were scientifically valid, they are unlikely to replicate a typical craving experience, which, as argued by both Tiffany (1990) and Kavanagh (2005), relies on habitual and difficult-to-replicate-cues. These include the environment (for example, walking past a favourite coffee shop) or an individualistic routine (for example, having a coffee at morning tea in the staffroom at work). Furthermore, the typical craving experience is unlikely to encompass cue exposure as extensive as what was contained in the experiment (abstinence, extensive imagery, direct exposure and exposure to a picture). Therefore, it is likely that individuals in the craving group craved coffee at a higher level than what they would in a typical craving experience. Although the exaggerated craving experience reduces the ecological validity of our memory impairment finding (that is, we are unlikely to see such large differences in memory performance if craving is lower), it strengthens the validity of our finding of no difference between groups in FOK judgement accuracy. Namely, if there is no difference when craving is exceedingly high, there is negligible possibility of there being a difference if craving is lower.

**Future Research**

The present research raises a number of questions for further research. Firstly, it would be beneficial to use the craving paradigm to determine the cognitive mechanisms of other metacognitive processes. These may include other forms of metamemory such as judgements-of-learning, forms of metacognitive strategies such as self-regulated learning, or metacognitive knowledge, such as higher-order thinking. Such an undertaking is important, as metacognitive ability is integral in academic performance (Dunning, Johnson, Ehrlinger, & Kruger, 2003), as well as the enhancement of academic ability (Gul & Shezad, 2012). Forms of metacognition that use conscious processing, once determined, can then be explicitly taught and

emphasised by teachers to improve the academic capabilities of students. Consequently, the phenomenon of craving can be used to determine the extent to which different metacognitive processes rely on deliberate, conscious processing or automatic, unconscious processing.

Finally, although the focus of this study was on coffee, other beverages also contain caffeine, such as tea, Coca-Cola and energy drinks. It would be useful to see, firstly, whether these beverages can be craved, and secondly, whether they can be craved to the extent that cognition is inhibited—this could be determined by using a task that has already demonstrated differences between the craving and control group in other substances. This would be of particular use, considering the high extent to which tea is consumed (38% of the Australian population; Australian Bureau of Statistics, 2014) and the increasing prevalence of the consumption of energy drinks (Trapp et al., 2014). It would also be a more complex undertaking than coffee, as some of these beverages have multiple facets that could be craved; for example, Coke-Cola and energy drinks contain both caffeine and sugar (Ruxton, 2014, and it has been demonstrated in previous research that sugar can be craved (Yanovski, 2003).

**Summary**

In conclusion, this experiment has provided important and novel evidence regarding the cognitive nature of FOK judgements, and supports Koriat's (1993) assertion that they are the result of automatic processing. It also extends and supports the finding that craving impairs cognition—in this case, explicit, long-term memory—through the novel paradigm of coffee craving. Furthermore, this research specifically demonstrates that craving impairs memory, but in this state of impairment, one still has an accurate assessment of memory for information that is

unrecalled. That FOK judgements are unhindered by craving has implications in numerous fields, as discussed. In summary, this research has added to the knowledge of the mechanisms of both memory and metacognition, both of which are pivotal components to the efficient functioning of individuals in day-to-day life.

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## Appendices

# Appendix A

## Ethical Documentation

Appendix A1: Human Research Ethics Committee Approval Letter

Appendix A2: Consent Form for All Participants

Appendix A3: Pre-study Information Sheet for Control Group

Appendix A4: Pre-study Information Sheet for Experimental Group

Appendix A5: Debrief Information Sheet for All Participants

# Appendix A1

## Human Research Ethics Committee Approval Letter

Social Science Ethics Officer
Private Bag 01 Hobart
Tasmania 7001 Australia
Tel: (03) 6226 1832
Fax: (03) 6226 7148
Human.ethics@utas.edu.au

HUMAN RESEARCH ETHICS COMMITTEE (TASMANIA) NETWORK

01 May 2015

Dr Matt Palmer
Psychology
Private Bag 1342

*Sent via email*

Dear Dr Palmer

Re: APPROVAL FOR AMENDMENT TO CURRENT PROJECT
Ethics Ref: H0012507 - The Effect of Caffeine Cravings on Cognitive Performance in a Mock-Juror Sample

Amendments:

*-The addition of Angus Ling and Josh Riza as student investigators (Honours in Psychology).*

*-The addition of Jim Sauer as an investigator.*

*-The use of updated stimulus materials.*

---

We are pleased to advise that the Chair of the Tasmania Social Sciences Human Research Ethics Committee approved the Amendment to the above project on 29/4/2015.

Yours Sincerely

Ethics Officer
Tasmanian Social Sciences HREC

## Appendix A2

### Consent Form for All Participants

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Tasmania 7250 Australia

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UTAS

### Factors that influence thinking and decision making

*Participant Consent Form*

1. I agree to take part in the research study named above.
2. I have read and understood the Information Sheet for this study.
3. The nature and possible effects of the study have been explained to me.
4. I understand that the study involves participating in a decision making task in which I will study word pairs and answer some questions about them. Additionally, I understand that the researcher will ask me to complete some brief questionnaires. These tasks will take approximately 60 minutes total to complete in total.
5. I understand that participation involves no foreseeable risks.
6. I understand that all research data will be securely stored on the University of Tasmania premises for five years from the publication of the study results, and will then be destroyed unless I give permission for my data to be archived.

   I agree to have my study data archived. (Note that your data will be stored anonymously.)

   Yes ☐ No ☐
7. Any questions that I have asked have been answered to my satisfaction.
8. I understand that the researchers will maintain confidentiality and that any information I supply to the researcher will be used only for the purposes of the research.
9. I understand that the results of the study will be published so that I cannot be identified as a participant.
10. I understand that my participation is voluntary and that I may withdraw at any time without any effect.

    I understand that I will not be able to withdraw my data after completing the experiment as my data will be anonymous

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Phone (03) 6324 3004 Fax (03) 6324 3168

matthew.palmer@utas.edu.au

Participant's name:

_____

Participant's signature:

_____

Date: _____

**Statement by Investigator**

☐ I have explained the project and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

If the Investigator has not had an opportunity to talk to participants prior to them participating, the following must be ticked.

☐ The participant has received the Information Sheet where my details have been provided so participants have had the opportunity to contact me prior to consenting to participate in this project.

Investigator's name:

_____

Investigator's signature:

_____

Date: _____

**Appendix A3:**

**Pre-study Information Sheet for Control Group**

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matthew.palmer@utas.edu.au

# Factors that influence thinking and decision making

*Information Sheet for Participants*

## 1. Invitation

You are invited to participate in a research study examining factors that affect cognitive performance. Cognitive performance refers to an individual's ability to perform processes such as attention, memory, perception and problem solving. The study is being conducted by Angus Ling and Josh Riza, who are completing Honours in Psychology, and Dr Matthew Palmer and Dr Jim Sauer of the Division of Psychology.

## 2. *What is the purpose of this study?*

The purpose of the study is to enhance our understanding of the factors which influence cognitive performance and the ability to make accurate decisions.

## 3. Why have I been invited to participate?

For this experiment, we are looking for people aged 17 years or more.

Your participation would contribute to research and understanding in this area. Participation in this study is voluntary – you are entirely free to choose to participate or not, and there will be no consequences if you decide not to participate. If you do participate, any information you provide will be anonymous and no participants in the experiment will be individually identifiable.

## 4. What will I be asked to do?

Participation would require approximately 60 minutes of your time on only one occasion and would take place in a room in the Psychology building on the UTAS campus. The study involves reading pairs of words and answering some questions about them. Additionally, participants will be asked to complete some brief questionnaires on issues relating to factors which may impair cognitive performance. The tasks will take approximately 60 minutes to complete in total.

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## 5. Are there any possible benefits from participation in this study?

We do not expect that the study will directly benefit participants. However, there may be benefits for the wider community. If we are able to determine whether something impairs cognitive performance our findings will have a number of implications for any real world circumstances in which optimal cognitive performance is required. For example, our findings may help in maximizing workplace productivity or in improving people's ability to make accurate decisions. This research may lead to a better understanding of the area of cognitive performance, as well as broadening your knowledge of scientific experimentation.

## 6. Are there any possible risks from participation in this study?

There are no specific risks anticipated with participation in this study. However, if you find that you are becoming distressed or fatigued you can discontinue the task at any time.

Additionally, you will be provided with support from the experimenters or, alternatively, we will arrange for you to see a counsellor at no expense.

## 7. What if I change my mind during or after the study?

That's fine - you are free to withdraw from the study at any time, and without providing an explanation. If you choose to withdraw during the study, your responses will be destroyed. If you complete the study, you will not be able to withdraw your data because it will be stored in anonymous form (and so we will not be able to identify which responses are yours).

## 8. What will happen to the information when this study is over?

The data from this study will be kept in secure storage on the University of Tasmania premises for a period of five years after any publications (e.g., in academic journals) that involve the data. After this period, the data will be archived. Only the researchers will have access to the raw data. The data will be stored anonymously. All responses will be anonymous and no identifying information will be collected from participants.

## 9. How will the results of the study be published?

The results of the study will be published in an academic journal. Once the study has been completed, you will be able to access the results by visiting the website below:

http://www.utas.edu.au/psychology/research/research-project-reports

No individual participants will be identifiable in the publication of the results.

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## 10. What if I have questions about this study?

If you would like to discuss any aspect of this study please feel free to contact us:

Angus Ling, (lingar@utas.edu.au) Josh Riza (jlriza@utas.edu.au), Dr Matthew Palmer (matthew.palmer@utas.edu.au) or Dr Jim Sauer (jim.sauer@utas.edu.au). We would be happy to discuss any aspect of the research with you. Once the information has been analyzed a summary of the findings may be obtained on request. You are welcome to contact us at that time to discuss any issue relating to the research study.

**Thank you for taking the time to consider this study.**

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. Please quote ethics reference number H12507.

**This information sheet is for you to keep. If you would like to participate in this study, please ask the researcher for a Consent Form to complete.**

**Appendix A4:**

**Pre-study Information Sheet for Experimental Group**

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# Factors that influence thinking and decision making

*Information Sheet for Participants*

## 1. Invitation

You are invited to participate in a research study examining factors that affect cognitive performance. Cognitive performance refers to an individual's ability to perform processes such as attention, memory, perception and problem solving. The study is being conducted by Angus Ling and Josh Riza, who are completing Honours in Psychology, and Dr Matthew Palmer and Dr Jim Sauer of the Division of Psychology.

## 2. *What is the purpose of this study?*

The purpose of the study is to enhance our understanding of the factors which influence cognitive performance and the ability to make accurate decisions.

## 3. Why have I been invited to participate?

For this experiment, we are looking for people aged 17 years or more.

Your participation would contribute to research and understanding in this area. Participation in this study is voluntary – you are entirely free to choose to participate or not, and there will be no consequences if you decide not to participate. If you do participate, any information you provide will be anonymous and no participants in the experiment will be individually identifiable.

## 4. What will I be asked to do?

Participation would require approximately 60 minutes of your time on only one occasion and would take place in a room in the Psychology building on the UTAS campus.

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The study involves reading pairs of words and answering some questions about them. Additionally, participants will be asked to complete some brief questionnaires on issues relating to factors which may impair cognitive performance. The tasks will take approximately 60 minutes to complete in total.

In addition, you would be asked to avoid consuming any caffeine on the day of the study until you have finished participating in the study (i.e., no coffee, no energy drinks, no caffeine tablets, etc.).

## 5. Are there any possible benefits from participation in this study?

We do not expect that the study will directly benefit participants. However, there may be benefits for the wider community. If we are able to determine whether something impairs cognitive performance our findings will have a number of implications for any real world circumstances in which optimal cognitive performance is required. For example, our findings may help in maximizing workplace productivity or in improving people's ability to make accurate decisions. This research may lead to a better understanding of the area of cognitive performance, as well as broadening your knowledge of scientific experimentation.

## 6. Are there any possible risks from participation in this study?

There are no specific risks anticipated with participation in this study. However, if you find that you are becoming distressed or fatigued you can discontinue the task at any time. Additionally, you will be provided with support from the experimenters or, alternatively, we will arrange for you to see a counsellor at no expense.

## 7. What if I change my mind during or after the study?

That's fine - you are free to withdraw from the study at any time, and without providing an explanation. If you choose to withdraw during the study, your responses will be destroyed. If you complete the study, you will not be able to withdraw your data because it will be stored in anonymous form (and so we will not be able to identify which responses are yours).

## 8. What will happen to the information when this study is over?

The data from this study will be kept in secure storage on the University of Tasmania premises for a period of five years after any publications (e.g., in academic journals) that involve the data. After this period, the data will be archived. Only the researchers will have access to the raw data. The data will be stored anonymously. All responses will be anonymous and no identifying information will be collected from participants.

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## 9. How will the results of the study be published?

The results of the study will be published in an academic journal. Once the study has been completed, you will be able to access the results by visiting the website below:

http://www.utas.edu.au/psychology/research/research-project-reports

No individual participants will be identifiable in the publication of the results.

## 10. What if I have questions about this study?

If you would like to discuss any aspect of this study please feel free to contact us:

Angus Ling, (lingar@utas.edu.au) Josh Riza (jlriza@utas.edu.au), Dr Matthew Palmer (matthew.palmer@utas.edu.au) or Dr Jim Sauer (jim.sauer@utas.edu.au). We would be happy to discuss any aspect of the research with you. Once the information has been analyzed a summary of the findings may be obtained on request. You are welcome to contact us at that time to discuss any issue relating to the research study.

**Thank you for taking the time to consider this study.**

This study has been approved by the Tasmanian Social Sciences Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, please contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or email human.ethics@utas.edu.au. The Executive Officer is the person nominated to receive complaints from research participants. Please quote ethics reference number H12507.

**This information sheet is for you to keep. If you would like to participate in this study, please ask the researcher for a Consent Form to complete.**

# Appendix A5:

## Debrief Information Sheet for All Participants

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### Participant Debriefing Information Sheet

### Social Science/Humanities Research

**Explanation of the experiment: The role of caffeine and cravings**

Thank you for participating in this study. Your participation is invaluable and will contribute to the research and understanding in this area. As you may have noticed, the study was actually examining the effect of caffeine cravings (the intense urge or desire to consume a specific substance, in this case, caffeine) on cognition. Previous studies have found that cravings reduce the cognitive resources that people can dedicate to tasks. We are looking at the effects of caffeine cravings on metacognition. For example, do cravings influence how well you can predict whether you will be able to remember something in the future?

**Why wasn't I told about the role of cravings for caffeine in this experiment?**

In order to ensure this study is conducted effectively, we were unable to disclose all aspects of the study beforehand. Studies have found that if participants are aware that a study is looking at cravings beforehand, the control group (those who were not supposed to experience cravings) may unintentionally start to crave during the testing process. This would have confounded the results obtained by the study, and would have limited the utility of the study.

**This study is entirely voluntary and confidential**

It is important to understand that your involvement in the study is completely voluntary, and you may still withdraw at any time. If you are uncomfortable with having been deceived, you may request that any information you have provided so far be destroyed without consequence, and without providing an explanation for this.

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We would like to again remind you that all information will be treated in a confidential manner, and your name will not be used in any publication associated with the study. Any materials from the study will be kept secure by the University of Tasmania's psychology department.

If you would like, the experimenters can provide or arrange for support, at no cost to you.

**What if I have questions about this research?**

If you would like to further discuss any part of this study, please do not hesitate to contact us via email Angus Ling, (lingar@utas.edu.au) Josh Riza (jlriza@utas.edu.au), Dr Matthew Palmer (matthew.palmer@utas.edu.au) or Dr Jim Sauer (jim.sauer@utas.edu.au). Once results from the study have been finalised, a summary of findings from the study may be obtained on request.

This study has been approved by the Tasmanian Social Science Human Research Ethics Committee. If you have concerns or complaints about the conduct of this study, you are able to contact the Executive Officer of the HREC (Tasmania) Network on (03) 6226 7479 or via human.ethics@utas.edu.au. Please quote ethics reference number H0012507.

**Thank you for taking the time to participate in this study.**

**This information sheet is for you to keep.**

# Appendix B

## Participation Reminder

Appendix B1: Reminder Email of Participation for the Control Group

Appendix B2: Reminder Email of Participation for the Experimental Group

## Appendix B1

### Reminder Email of Participation for the Control Group

**Thank you for agreeing to participate in our study. Please see below for instructions:**

**Reminder Email Regarding Your Participation in the Coffee and Cognition Study**

Hello, (*insert name*)

Just a quick email to remind you that you are scheduled to participate in our study on **Wednesday** the 9th of September from 9:00 AM to 10:30 AM. The study is being held in room 103 in the psychology research building but **we will meet you in the psychology foyer area on the ground floor of the social sciences building at 9:00 AM.**

Please note that you must be a regular coffee drinker (at least one cup per day) to participate in this study.

**Continue coffee consumption as you normally would on day of testing**

You will be reimbursed for your time. If you are **not a first year psychology student**, or you **are a first year psychology student who has fulfilled course credit requirements** you will be paid $20in the form of a Coles/Woolworths voucher.

If you are a **first year psychology student who has not fulfilled your course credit requirements you will receive 90 minutes of course credit**.

If you have any further questions, you can email either Angus or myself or ask us at your appointment on Wednesday.

If you need to cancel or reschedule the appointment, please notify either Angus or myself ASAP so that we can reschedule (if applicable).

Thank you,
Angus Ling & Joshua Riza

## Appendix B2

### Reminder Email of Participation for the Experimental Group

Hello (*insert name*),

**Thank you for agreeing to participate in our study. Please see below for instructions:**

**Reminder Email Regarding Your Participation in the Coffee and Cognition Study**

Just a quick email to remind you that you are scheduled to participate in our study on **Friday** the 11th of September from 11:00 AM to 12:00 PM. The study is being held in room 103 in the psychology research building but **we will meet you in the psychology foyer area on the ground floor of the social sciences building at 11:00 AM.**

Please note that you must be a regular coffee drinker (at least one cup per day) to participate in this study.

**Please abstain from Coffee on the day testing**

You will be reimbursed for your time. If you are **not a first year psychology student**, or you **are a first year psychology student who has fulfilled course credit requirements** you will be paid $20in the form of a Coles/Woolworths voucher.

If you are a **first year psychology student who has not fulfilled your course credit requirements you will receive 90 minutes of course credit**.

If you have any further questions, you can email either Angus or myself or ask us at your appointment on Friday.

If you need to cancel or reschedule the appointment, please notify either Angus or myself ASAP so that we can reschedule (if applicable).

Thank you,
Angus Ling & Joshua Riza

# Appendix C

## Coffee Craving Manipulation and Measurement Documentation

Appendix C1: Exposure and Imagery Task for the Control Group

Appendix C2: Exposure and Imagery Task for the Experimental Group

Appendix C3: Visual Analogue Scale for Level of Coffee Craving Across Time-points

Appendix C4: Trait Coffee Craving Questionnaire

Appendix C5: Coffee Dependence Questionnaire

# Appendix C1:

## Exposure and Imagery Task for the Control Group

### Holiday Imagery Task

I want you to walk up to the table and to pick up the jug of water and pour yourself a cup. Now proceed to hold the cup as you normally would. While holding your cup, sit down in the chair. As you do this, focus on your favourite holiday. Imagine what it would be like to be on this holiday right at this moment. Keep imagining this until I speak again *(8 second pause).*

Now pay attention to any smells and sounds associated with your favourite holiday. Imagine again what it would be like to be on your favourite holiday right at this moment. Keep focusing on the sights and sounds of your holiday until I speak again *(8 second pause).*

Now stand with your cup of water and walk over to the table where you poured yourself a cup and place your cup on that same table. As you do so, imagine for the last time, what it would be like to be on your favourite holiday *(8 second pause).*

## Appendix C2:

## Exposure and Imagery Task for the Experimental Group

### Coffee Imagery Task

On the table, you will see a hot jug of freshly made coffee and an empty white mug. Take a moment to look at these objects.

Now, I want you to walk up to the table and to pick up the jug of freshly made coffee and pour yourself a cup and to pay attention to the sound of the coffee being poured into the cup. Now proceed to hold the cup of coffee as you normally would. As you do this, focus on the weight in the cup now that it is full. Imagine what it would be like to drink a cup of your favourite coffee right at this moment. Keep imagining this until I speak again *(8 second pause).*

Now sit down in the chair with your cup of coffee and pay attention to the smell of the coffee and the colour and imagine again what it would be like to have a cup of your favourite coffee right at this moment. Pay attention to any steam as it slowly curls and rises above the cup. Keep focussing on the sight and smell of the cup of coffee until I speak again *(8 second pause).*

Now stand with your cup of coffee and walk over to the table where you poured yourself a cup and place your cup on that same table. As you do so, imagine for the last time, what it would be like to drink a cup of your favourite coffee *(8 second pause).*

## Appendix C3:

## Visual Analogue Scale for Level of Coffee Craving Across Time-points

**Coffee Craving Intensity Scale**

**1. When you first arrived here (before testing began), how strong was your desire for coffee?**

*Please draw a vertical mark on the line below*

0 |----------| 100

No desire — Extremely strong desire

**2. Immediately after the first induction task (where you imagined a scenario), how strong was your desire for caffeine/coffee/an energy drink?**

*Please draw a vertical mark on the line below*

0 |----------| 100

No desire — Extremely strong desire

**3. Immediately after the second induction task (where you imagined a scenario), how strong was your desire for coffee?**

*Please draw a vertical mark on the line below*

0 |----------| 100

No desire — Extremely strong desire

**4. <u>Right now</u>, how strong is your desire for coffee?**

*Please draw a vertical mark on the line below*

| 0 | I---------- | 100 |
|---|---|---|
| No desire | | Extremely strong desire |

## Appendix C4:

## Trait Coffee Craving Questionnaire

### Attitudes to Caffeine Questionnaire

**Instructions:** Circle the extent to which each item describes you, from 1 to 7, using:

---

**1**: Not at all like me

**2**: Not Quite like me

**3**: Not much like me

**4**: Neutral

**5**: Somewhat like me

**6**: Quite like me

**7**: Very much like me

---

1. I consume coffee to cheer me up when I am down.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

2. I often consume coffee when I am bored.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

3. I consume more coffee than is good for me.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

4. I never crave coffee.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

5. My desire for coffee often seems overpowering.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

6. The thought of coffee often distracts me from what I am doing (e.g. watching TV).

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

7. I usually find myself wanting coffee during the morning.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|

| |
|---|
| **1**: Not at all like me<br>**2**: Not quite like me<br>**3**: Not much like me<br>**4**: Neutral<br>**5**: Somewhat like me<br>**6**: Quite like me<br>**7**: Very much like me |

8. If I crave coffee I can't get it out of my head until I drink some.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

9. I often go to the shop for something else and end up buying coffee.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

10. Coffee often preys on my mind.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

11. When I am upset coffee comforts me.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

12. I would describe my craving for coffee as more intense than a simple desire or longing.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

13. Nothing but coffee will satisfy my coffee cravings.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

14. Even when I do not really want anymore I will carry on drinking coffee.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

15. I like the taste of coffee.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |

## Appendix C5:

## Coffee Dependence Questionnaire

### Coffee Dependence Questionnaire

**Instructions: While answering this questionnaire:**

- Think about the last week and circle the answer most appropriate to you
- Think about the caffeinated beverages you consume most frequently
- Please circle the answer that is most appropriate to you

**1. Do you find yourself thinking about when you will next be able to have another coffee?**

| | | | |
|---|---|---|---|
| Never | Sometimes | Often | Nearly always |

**2. Is consuming coffee more important than anything else you might do during the day?**

| | | | |
|---|---|---|---|
| Never | Sometimes | Often | Nearly always |

**3. Do you feel your need for coffee is too strong to control?**

| | | | |
|---|---|---|---|
| Never | Sometimes | Often | Nearly always |

**4. Do you plan your days around getting and consuming coffee?**

| | | | |
|---|---|---|---|
| Never | Sometimes | Often | Nearly always |

**5. Do you drink coffee in a particular way in order to increase the effect it gives you?**

| | | | |
|---|---|---|---|
| Never | Sometimes | Often | Nearly always |

**6. Do you drink coffee morning, afternoon, and evening?**

| | | | |
|---|---|---|---|
| Never | Sometimes | Often | Nearly always |

**7. Do you feel you have to carry on drinking coffee once you have started?**

| Never | Sometimes | Often | Nearly always |
|---|---|---|---|

**8. Do you want to consume more coffee when the effect starts to wear off?**

| Never | Sometimes | Often | Nearly always |
|---|---|---|---|

**9. Is getting the effect you want (i.e. increased energy/alertness) more important than the particular coffee you use?**

| Never | Sometimes | Often | Nearly always |
|---|---|---|---|

**10. Do you find it difficult to cope with life without coffee?**

| Never | Sometimes | Often | Nearly always |
|---|---|---|---|

# Appendix D

## Screenshots of E-Prime Program

Appendix D1: Introductory Instructions

Appendix D2: Encoding Phase Instructions

Appendix D3: Presentation of Word-pairs (Encoding Phase)

Appendix D4: Recall Instructions

Appendix D5: Target-word Recall

Appendix D6: FOK Judgement Instructions

Appendix D7: FOK Judgements

Appendix D8: 4AFC Recognition Task Instructions

Appendix D9: 4AFC Recognition Task

Appendix D10: Holiday Image

Appendix D11: Coffee Image

## Appendix D1

## Introductory Instructions

**This experiment is about memory for word-pairs (e.g., fence-shirt). During the experiment, you will be shown some pairs of words and asked questions about them later.**

**If you have any questions or need to take a break during the study, please ask the experimenter.**

## Appendix D2

## Encoding Phase Instructions

**In the first part of the experiment, you will be shown some word-pairs (e.g., fence-shirt) one pair at a time.**

**You will be tested on these words later. You will be shown the first word of each pair and you will be asked to try to remember the second word (e.g., fence_____).**

**Please study the word-pairs as carefully and as quickly as you can.**

**PRESS THE SPACEBAR TO CONTINUE**

## Appendix D3

### Presentation of Word-pairs (Encoding Phase)

SHOVEL  BRANDY

Press ENTER to continue

## Appendix D4

## Recall Instructions

**Next, you will be shown the first word of each pair and asked to type the second word of that pair. On each occasion, please type the second word of the pair and press ENTER.**

**Please answer as accurately and as quickly as you can. If you do not know the answer please press ENTER to proceed to the next word.**

**PRESS THE SPACEBAR TO BEGIN**

## Appendix D5

## Target-word Recall

**ATOM**

**Type the matching second word then press ENTER.**

_

## Appendix D6

## FOK Judgement Instructions

**Next, you will see the first word of each pair and we would like you to think about whether you will recognise the matching second word from a list of 4 words.**

**For each word, type a number from 0 (definitely will NOT recognise the second word) to 100 (definitely WILL recognise the second word)**

**Cyclone**
**1. Potato**
**2. Car**
**3. Speaker**
**4. Coat**

**Please press the SPACEBAR to continue**

## Appendix D7

## FOK Judgements

**CAMERA**

**Will you be able to recognise the matching word from a list?**

**Type a number from 0 (definitely not) to 100 (definitely yes) then press ENTER**

## Appendix D8

## 4AFC Recognition Task Instructions

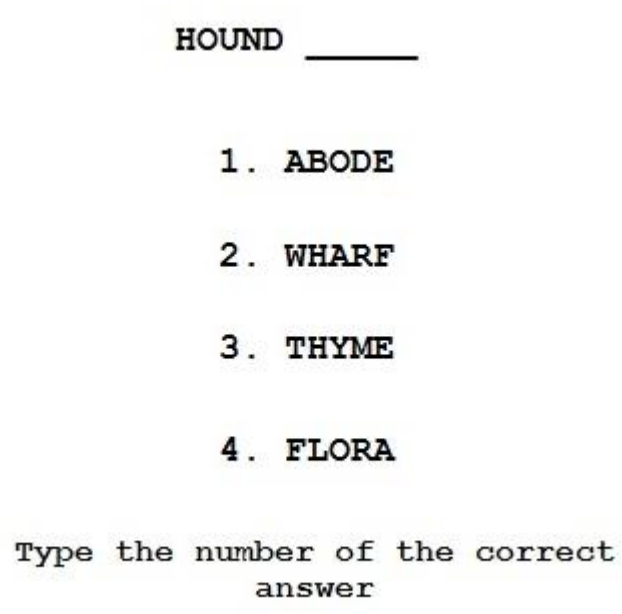
**For each trial, type the number of the correct word (1, 2, 3 or 4) that was paired with the first word. If you do not know the answer for a trial, please provide your best guess. When you type your answer you will automatically continue to the next trial.**

**Cyclone_____**
**1. Potato**
**2. Car**
**3. Speaker**
**4. Coat**

**Please press the SPACEBAR to begin**

## Appendix D9

## 4AFC Recognition Task



## Appendix D10

## Holiday Image

It's now time for a short break.

The study will automatically continue soon.

## Appendix D11

## Coffee Image

It's now time for a short break.

The study will automatically continue soon.

## Appendix E

### Diagram of Experimental Procedure